IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Ushio et al.

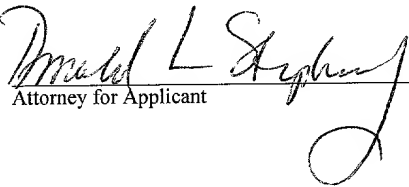Application No. New Application

Filed: Herewith

For: LAYER-THICKNESS DETECTION METHODS
        AND APPARATUS FOR WAFERS AND THE
        LIKE, AND POLISHING APPARATUS

Examiner: (Unknown)

Date: June 13, 2001

Art Unit: (Unknown)

BOX PATENT APPLICATION
COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

PRELIMINARY AMENDMENT

Please amend the subject application as follows:

In the Specification:

Please add on page 1, before "Field of the Invention":

Cross-Reference to Related Application

This application is a divisional of co-pending U.S. Patent application no. 09/316,082,
filed on May 20, 1999.

Replace the paragraph starting at page 1, lines 27-31, and ending at page 2, lines 1-8, with the
following paragraph:

Responsive to the need to achieve ever-increasing device density along with ever-
decreasing feature sizes, the microlithography industry has developed microlithography
apparatus that utilize extremely short wavelengths of light, such as deep-UV light, but at large
numerical apertures. Projection optics used in such apparatus have extremely short focal ranges.
The focal ranges are now so short that the uneven surface that results from stacking multiple

layers atop one another during manufacture of an integrated circuit is no longer in sharp focus from peaks to valleys of the surface. Consequently, it has become increasingly important to planarize the surface of the wafer (at least within exposure areas) accurately between certain layer-formation steps. It is also important to perform a planarization step after embedding an inlay of a metal electrode layer to form inter-layer connecting plugs and the like.

Replace the paragraph at page 6, lines 7-12, with the following paragraph:

In view of the above-summarize shortcomings of the prior art, an object of the invention is to provide, *inter alia*, simple and convenient detection methods by which the thickness of one or more layers on the surface of a workpiece (e.g., wafer) can be determined. Such determinations are especially useful in the determination of a process endpoint.

Replace the paragraph at page 17, lines 17-19, with the following paragraph:

FIG. 10 is a schematic plan view, with respect to the Sixth Embodiment and Example 6, of various regions of a representative device pattern, such as a pattern for a microprocessor.

Replace the paragraph starting at page 19, lines 21-31, and ending at page 20, lines 1-8, with the following paragraph:

Typically, the target surface of a semiconductor wafer or analogous workpiece comprises a laminate of multiple thin-film layers each defining a respective pattern extending in two dimensions. Each layer typically has a respective pattern. The patterns are typically interconnected with each other in three dimensions. As shown schematically in FIG. 1, a probe light P is incident on a target surface to produce rays of signal light 1, 3, 5, 7 reflected from the target surface. The signal light comprises light reflected from various surfaces 2, 4, 6, 8. For example, some of the signal light 1 is produced by reflection of probe light P from the surface 2 of an outermost layer on the target surface. Other signal light 3, 5, 7 is produced by reflection of probe light from surfaces 4, 6, 8, respectively, of one or more layers situated beneath the outermost layer. Such reflection from multiple layers results in a signal light having a complex interference pattern. A spectral characteristic (e.g., spectral reflectance) of signal light reflected from a target surface as shown in FIG. 1 usually differs greatly from a similar spectral

characteristic of signal light reflected from a "blank" target surface. (A "blank" target surface is a planar surface. It can be patterned but is desirably not patterned.)

Replace the paragraph at page 23, lines 22-30, with the following paragraph:

A suitable measure of wavelength dispersion is the standard deviation or variance of the signal-light wavelength. As the surface of the wafer is being polished, the signal-light dispersion exhibits a change. The dispersion exhibits a rapid increase immediately before and after the surface of the wafer is planarized. As in the first embodiment, the effect of pattern interference appears prominently immediately before and after planarization is achieved during polishing. The reflectance also changes rapidly with respect to wavelength as polishing progresses, which is believed to be the cause of the increase in spectral reflectance.

Replace the paragraph starting at page 27, lines 12-31, and ending at page 28, lines 1-2, with the following paragraph:

This example differs from Example 1 in that, in Example 2, the quotient (global minimum spectral reflectance)/(global maximum spectral reflectance) was used as the measurement parameter. The signal processor 17 (FIG. 2) calculates local minima and local maxima by differentiating the spectral reflectance signal. From such local minima and maxima, the signal processor 17 obtains the global maximum, the global minimum, and the quotient (global maximum/global minimum). To obtain the global maximum and global minimum, the signal processor compares each value of the local maxima and the local minima, respectively. The signal processor then determines which local maximum has the greatest signal magnitude and identifies that particular local maximum as the global maximum, and determines which local minimum has the lowest signal magnitude and identifies that particular local minimum as the global minimum. The measurement parameter (global maximum/global minimum) is monitored with respect to the thickness of the layer being polished as polishing progressed. FIG. 5 depicts the change in the quotient with respect to layer thickness as polishing progressed. As shown in FIG. 5, the quotient exhibits a rapid decrease around the polishing endpoint (at which time the surficial steps had been eliminated by polishing). Thus, by monitoring the quotient in the vicinity of the polishing endpoint, the moment to cease polishing is determined easily with high accuracy.

Replace the paragraph at page 28, lines 11-17, with the following paragraph:

This example differs from Example 1 in that, in Example 3, the wavelength dispersion of the spectral reflectance was determined for each measured value of the spectral reflectance, and the dispersion values were used as the measurement parameter. (The wavelength dispersion of the spectral reflectance is the variance of reflectance as measured over a range of wavelengths, i.e., over a spectral range. The "variance" is the square of the standard deviation, as known in the art.)

Replace the paragraph at page 29, lines 11-20, with the following paragraph:

The manner in which the optimal wavenumber is determined depends on the profile and dimensions of the pattern defined by the surficial layer on the wafer. Hence, the optimal wavenumber component can be calculated from the profile and dimensions of the pattern. However, multiple wavenumber components can be selected, and changes in each wavenumber component can be simulated with respect to the change in the thickness of the layer being polished. In this instance, the wavenumber component having a plot that changes most rapidly in the vicinity of the polishing endpoint desirably is selected as the optimal wavenumber component.

Replace the paragraph at page 34, lines 13-27, with the following paragraph:

Therefore, the reflectance of probe light from a pattern on a wafer is dependent upon the degree of fineness of the device pattern and results from differences in the interference phenomena exhibited by probe light reflected from such patterns. In this regard, it will be recalled in the discussion above regarding FIG. 1 that light reflected from a patterned laminate of thin films is a superposed interference phenomenon. The interference is due to amplitude splitting due to the thickness of the layers and wave-surface splitting due to interaction of probe light with the features of the pattern. These pattern-dependent interference phenomena are generated between features within the spatial coherence length of the illuminating optical system. (The "spatial coherence length" is a distance, on the device pattern, in which light

irradiated onto the pattern has coherency.) Therefore, these pattern-dependent interference phenomena do not occur when the feature width is larger than the coherence length.

Replace the paragraph at page 45, lines 14-31, with the following paragraph:

(a) local maximum of a spectral characteristic of signal light,

(b) local minimum of a spectral characteristic of signal light,

(c) (local maximum of a spectral characteristic) - (local minimum of the spectral characteristic),

(d) (local minimum of a spectral characteristic) / (local maximum of the spectral characteristic),

(e) largest local maximum of a spectral characteristic of signal light,

(f) smallest local minimum of a spectral characteristic of signal light,

(g) (largest local maximum of a spectral characteristic) - (smallest local minimum of the spectral characteristic),

(h) (smallest local minimum of a spectral characteristic) / (largest local maximum of the spectral characteristic),

(i) dispersion of a spectral characteristic of signal light, and

(j) an appropriate component of a Fourier transform of a spectral characteristic of signal light (e.g., a component whose magnitude is maximum).

Replace the paragraph at page 49, lines 17-30, with the following paragraph:

The surface 47 of the wafer 46 can be, e.g., an insulating layer formed on a semiconductor device pattern on the wafer 46. The source 41 of probe light P is adjusted to a suitable spatial coherence length by adjusting the slit width in the spatial coherence unit 42. (The spatial coherence length is a distance, on the device pattern, in which the irradiated probe light has coherency.) The spatial coherence length can be varied by adjusting the beam diameter of the probe light. The probe light P passes through the lenses 43a, 43b and the beamsplitter 44, is collimated by the collimator lens 45, and is illuminated onto the surface 47 of the wafer 46. Signal light S reflected from the surface 47 carries information regarding the surface 47. The signal light S passes through the lenses 48a, 48b, 48c. Zeroth order signal light S propagates to

the grating 50 that disperses the zeroth order light according to wavelength. The wavelength-dispersed signal light is detected by the sensor 51.

Replace the paragraph starting at page 54, lines 21-31, and ending at page 55, lines 1-3, with the following paragraph:

In performing a comparison of the measured pattern with a stored pattern based solely on cross-correlation coefficients, a determination of the film thickness of a measured pattern can be difficult depending on the type of the measured pattern. Hence, in addition to comparing cross-correlation coefficients associated with the signal-light intensity profiles, it is desirable to calculate cross-correlation coefficients of Fourier-transformed theoretically calculated intensity profiles (of stored data) with a Fourier-transformed intensity profile of an actual measured intensity profile so as to obtain multiple cross-correlation coefficients. It is also desirable to compare the multiple cross-correlation coefficients with each other or to compare a Fourier component of the measured signal-light intensity profile with one or more Fourier components of the stored signal-light intensity profile. It is even more desirable to use both of these comparison procedures.

In the Claims:

Please cancel claims 1-9, 11, and 27-40 without prejudice or disclaimer.

REMARKS

Consideration and entry of this amendment are requested before commencing substantive examination of the subject application.

The amendments to the specification are to correct readily discernible errors. No new matter is submitted.
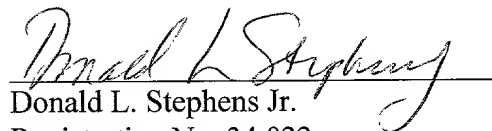
As a result of the claim amendments, claims 10 and 12-26 are now pending.

The subject application is a Divisional of a co-pending "parent" application (no. 09/316,082). Hence, this preliminary amendment. The claims now pending, as a result of this amendment, in the subject application are the claims of Group II, as denoted in a restriction requirement dated July 3, 2000, in the parent application.

Respectfully submitted,

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Marked-up Version of Amended Claims and Specification
Pursuant to 37 C.F.R. §§ 1.121(b)-(c)

In the Specification:

Please add on page 1, before "Field of the Invention", line 5:

--Cross-Reference to Related Application

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